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Sizing Hints
for the
Practical Slasher-man

CORN PRODUCTS REFINING CO.
ARGO PLANT.
ARGO, ILLINOIS

SIZING HINTS

for the

PRACTICAL SLASHER-MAN

By

W. R. CATHCART, Ph. D.

Technical Director Textile Department
Corn Products Refining Company

COMPLIMENTS
of
CORN PRODUCTS REFINING COMPANY
New York

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To the Textile Industry:

This booklet is offered to the manufacturers of textiles with the hope it will prove both interesting and valuable. It does not advocate any striking innovations in sizing-practice. The effort has been made to lay emphasis upon certain essentials, in a manner helpful to superintendents and foremen. This is entirely in line with our long established policy of Service and Co-operation in solving the problems of the practical man. To make the booklet of additional value for reference, a collection of tables is included giving information useful, but frequently not at hand in convenient form. It is hoped this publication may fill an existing need, serve to awaken interest and encourage investigation.

Respectfully,

CORN PRODUCTS REFINING COMPANY.

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Preparation of Sizing Mixture

THE fundamental point in the preparation of any sizing mixture is *accuracy*. Accuracy in measuring and weighing the constituent parts of a sizing mixture is absolutely essential to secure uniform results in dressing yarns. The formula will vary with the requirements of the individual case and should be adjusted and balanced after an investigation of the special circumstances. With any formula, accuracy is indispensable. With proper equipment, *accuracy* is not more difficult than *inaccuracy*.

Water

The amount of water used should always be measured and not guessed or estimated. To do this conveniently the diameter of the kettle should be carefully measured and the number of gallons per inch of depth calculated. (See Table p. 36.) A given depth in inches will represent the number of gallons needed. This may be marked permanently and clearly on a rod which should be used only for measuring. Another and perhaps surer method of always getting an exact and uniform water measurement is to provide an overflow pipe with a valve at the proper height in the side of the kettle. This pipe should not deliver directly into a closed waste pipe, but should be so arranged that the overflow runs into an open funnel connected with the waste-pipe. The water supply at the top of the kettle should also run into an open funnel which allows the operator to see whether water is actually flowing into the kettle and will show at once whether the valve leaks or whether it has been tampered

with while the size is in the kettle. The method of operation would then be as follows:

The operator first opens the valve in the side of the kettle and then admits the water by opening the supply valve at the top of the kettle. Water is allowed to flow into the kettle until it overflows at the side opening. Now, the supply valve is closed and when water ceases to run from the overflow this is likewise closed. It is manifest that this procedure always insures a uniform amount of water in the kettle. Some plants adopt the practice of mixing a part of a kettle, three-quarters, one-half or one-quarter, according to requirements, when new size is needed towards the end of the working hours, so that little or no size is left over after closing for the day. This has some advantages as fresh size is better than size which has been allowed to cool and stand and then heated over again. In cases where such fractional charges are made the overflow device must be duplicated at different heights or measuring rods with the proper mark used. If fractional charges are in use then each kettle should have a chart showing what weight of starch and other ingredients are to be used with the varying amounts of water. It is true that varying charges are more liable to personal error than the fixed charge and should only be used when the operator is reliable and careful. The fixed charge with the side overflow seems to be practically "fool-proof."

Starch

After the proper amount of water is in the kettle the stirrer is started and the starch is added rather gradually. The practice of measuring the starch by volume, in pails or other containers, should be discouraged and in fact prohibited. All starch

should be *weighed.* Weighing alone will insure the accurate amount of starch in the mixture. Arrangements should be made so that weighing will be convenient and easy for the operator and there should be no temptation to omit this operation and rely upon guess-work. Scales of proper capacity should be conveniently placed with reference to the starch-bin and size-kettle and should never be removed from the position selected. The main objections of mixers to weighing starch are confined to the inadequate weighing facilities provided. For instance it should not be necessary to use small pails for weighing. This introduces chances of error and requires the operator to make several trips from the scales to the kettle. If two suitable containers are provided, both of these could be placed at once on the scale-platform so that one taring and weighing are sufficient. The charge being divided in two equal containers of convenient size and form, permits one man to handle the charge comfortably, unassisted. (Two discarded roving cans of proper size have been used to advantage.) *The stirring of the starch and water should be in operation at least five minutes before steam is turned into the kettle.* A little longer will do no harm.

Tallow Softeners and Compounds

These ingredients should be accurately weighed in a proper container and added to the mixture in the kettle when slightly warm, but before the boiling point is reached.

Boiling

After the starch and water have been stirred *at least five* minutes the steam is turned on. The

valve may be opened to full capacity until the boiling point is reached. The time consumed in reaching the boiling point depends upon the dryness and pressure of the steam. The steam lines, of course, should be well insulated and if necessary properly trapped to keep all condensation from the lines out of the kettle. When the bubbles of steam pass freely through the mass and reach the surface the boiling point has been attained. *At this point the time should be taken and the boiling continued for at least forty-five minutes before using the mixture.* When the boiling point is reached the steam-valve should be throttled to a point where the boiling is maintained and yet the contents not forced out of the kettle. This adjustment can be easily secured, particularly if the steam valve supplying the kettle is by-passed by a small quarter inch pipe carrying a valve. The small valve can be more easily adjusted and is not so apt to be disturbed by jarring.

Attention should be specially called to the fact that irrespective of the amount of water used at the outset what actually counts in the sizing operation is the volume of the finished size, just before it is transferred to the size-box. Due regard should be given to this measurement. If for any reason steam should be abnormally wet or the water valve leaky, the final concentration will be unfavorable in spite of all accuracy used in measuring and weighing. For every formula there is a certain percentage increase of volume, calculated upon the original volume of water used, due to the condensation of the steam, the expansion of starch and the expansion caused by the elevation of the temperature. Should this increase show any abnormality the cause should be investigated. A method sometimes adopted is to use purposely an insuffi-

cient quantity of water at the start and just before the boiling is completed add sufficient water to make the required volume. The boiling, of course, must be continued during the addition of the water so that the mixture is boiling when the full quantity is reached. This must be done with great care. Inattention would spoil the whole mixture.

If the equipment includes a storage tank the charge is transferred and kept hot by means of a steam-jacket or a closed steam-coil and used as needed. If, however, the mixture is used direct from the kettle a closed steam coil should be used to keep the mass just boiling until exhausted.

The boiling should be continued in the size-box where the evaporation is supposed to compensate for any dilution caused by the injection of steam. A steam jacketed size-box is not included in the usual equipment. Such an installation, having no compensating dilution from steam, is liable to cause an undesirable concentration which must be controlled, preferably by the injection of steam.

Size-Box

In order to secure uniform results, the conditions in the size-box must be kept as constant as possible. Assuming that the speed of the slasher is constant there are two variable factors which should be controlled with care.

1st. The level of the size must be kept constant. A variation in the level means a variation of the time during which the yarn is in contact with the size. The result is lack of uniformity. If the level is controlled by the intermittent opening and closing of a valve by the operator the chances of irregularity are great on account of the personal factor involved. The introduction of a constant level device, preferably of the overflow type in

connection with a circulating system, will solve this question with entire satisfaction.

2nd. The temperature of the size in the size-box must be kept constant. The viscosity or fluidity of any size-mixture will vary with the temperature. The facility with which a size-mixture is absorbed by the yarn will vary with the viscosity of the paste. It is therefore clear that for a uniform absorption, which means a uniform dressing, a constant temperature should be maintained. Having determined for any given formula and type of work the most favorable temperature—this may be at the boiling point or slightly below—this temperature should be maintained as nearly constant as possible. Here again the personal factor is uncertain and may be entirely eliminated by the use of a temperature controller.

Slasher tenders are frequently annoyed by the thinning of the size in the size-box. Sometimes this thinning is due to the nature of the starch, as in the case of potato starch size which becomes progressively thinner the longer boiling is continued. However, in the case of corn starch, the "thinning down" is always due to excessive condensation of steam in the size box. It is customary to neutralize this effect by adding starch directly to the size-box. Of course, this introduces at once an element of inaccuracy. It is difficult for the most experienced men to estimate the proper quantity of starch to add, and usually the additional starch is not weighed. A scoopful, a half-a-pail or a few handfuls are taken according to the notion of the operator. The worst of all is when the additional starch is simply stirred up with water and poured into the box. When a strengthening of the size is decided upon, the approved quantity should be stirred with water and brought to the boiling

point in a pail or small container and only the cooked paste should be used. By all means the cause of the trouble should be removed: first, by using a starch which is not broken down by protracted boiling; and, second, by taking the proper precautions to admit only dry steam into the size-box. Proper insulation and trapping of the steam lines will accomplish this result. If these points are overlooked all efforts to be accurate and obtain uniform conditions are rendered ineffective.

Equipment

It is not intended to enter upon a description of the equipment of a slasher-room. The practical man is already familiar with the general outlay. There are, however, certain details, taken for granted or entirely overlooked, whose importance should be somewhat emphasized. The difference in attention to so called minor matters marks the difference between economical, efficient work and work which is otherwise.

The Size-Kettle

The cylindrical iron vessels used for boiling the size are all fashioned more or less after the same pattern and vary in capacity and number according to the requirements of the individual plants. The provisions for draining off a charge, introducing steam and water show a great similarity. The modification of the water connection suggested above (page 3) could be adopted with advantage, also the side overflow already commented on (page 3).

The stirring device is certainly worthy of more attention. This frequently consists of a shaft with two cross-arms, one placed near the bottom and the

other so near the top that it does almost no work in agitating the contents. The number of revolutions per minute varies considerably and is often not adjusted to get the best mixing results. Very frequently the contents moves in an orderly circular procession with no violent beating of the solid material which is to be put in suspension, or of the fatty matter which must be emulsified. The imperfectly gelatinized starch residue, sometimes found caked on the bottom of kettles having inefficient stirring mechanism explains the reason for the criticism. The remedy for this condition is very simple. The lower arm should be placed as near the bottom of the kettle as the construction will allow. The upper arm should be adjusted to the depth of the water so that it is covered before the addition of the starch. The mere addition of three or four vertical baffle-plates to the side of the kettle will add considerably to the agitation without increasing the speed of the paddles. These baffle-plates may be installed by simply bolting or riveting to the side of the kettle in positions symmetrical with respect to the circumference, pieces of angle iron of proper length. For the ordinary kettle a projection of three inches towards the center is sufficient. A propeller of two or three blades with a pitch similar to the screw of a ship gives very efficient stirring and does not require a very high rate of speed. The diameter and speed of such a stirrer, of course, would depend upon the dimensions of the kettle.

The outside wall of the kettle should be covered with a thick coating of insulating material, especially if there is no storage kettle and if the size remains in the kettle for some time. Such a covering not only conserves steam, but also minimizes the dilution of the size by the condensation of the

steam injected into a mixture which has fallen in temperature. It is true that some object to such insulation on the ground that the metal of the kettle is kept hot, and the water therefore becomes too warm before the starch is added. Experience will show that this fear is unjustified.

Circulating Systems

It is not within the scope of this discussion to go into any detailed description of the circulating system or attempt an exhaustive exposition of the arguments for and against its adoption. Generally speaking, the objections are not well founded, and such installations are growing more popular, especially with the larger plants.

The object of the circulating system is to maintain the size at a uniform concentration, at a uniform level in the size-box and at a uniform temperature. The importance of all of these factors is self-evident.

A storage tank, as separate and distinct from the mixing or boiling kettle, is almost always used in connection with a circulating system. This is by far the better practice. The storage tank should not be heated by an open steam-jet, but by a steam-jacket, or closed steam-coil. The tank should be provided with a mechanical stirrer and should by all means be covered on the outside with a good insulating coating.

The purpose of the steam-jacket or coil is not to boil the size, but to keep the mixture just at the boiling point so that there will be no excessive condensation of steam in the size-box. For this reason the jacket need not and really should not extend from bottom to top of the tank. The surrounding of the lower third of the tank is quite sufficient. In the same way, if a closed coil is used this should

not be very large, four or five turns are ample. Preferably all inside joints in the coil should be welded to avoid leaks. The coil is not only a more economical installation than the jacket, but also more efficient as far as steam is concerned.

The stirring mechanism is intended to keep the mass in motion so that the heat will be equally distributed. Violent agitation should be avoided.

Pipe Lines

Brass pipes are, of course, most desirable for transferring the size over its circulating route although galvanized iron is frequently adopted. The relative merits of these materials are well enough known. Above all things, all pipe lines through which hot size is moved should be well insulated. A circulating system with uncovered lines becomes a cooling system, to the cost of the coal pile and detriment of the size.

Pumps

The circulation of the size is maintained by pumps varying in type and number according to the tastes of the management and requirements of the plant.

Waste Pipes

Cleanliness in the preparation and handling of size should rank equally with accuracy or any other important factor. Starch after all is a food product and as such is subject to contamination and fermentation, which change its properties and produce substances which are quite different from starch. The strongest safeguard against these undesirable changes is cleanliness. The equipment should be so arranged that the operator can keep the whole system clean, without undue exertion and loss of

time. In short, cleaning must be made as convenient as possible.

The size-kettle, storage-tank and size-box should all have waste-pipes connected with the sewer so that they may be separately and quickly drained when necessary. In addition there should be provided accessible water connections to be used for washing out all containers at proper intervals. Similar precautions should be observed in regard to the pipe lines used for transferring the size. Steam connections at suitable points should be installed on all lines used for size for blowing out and thoroughly cleansing the entire system.

Sizing Materials

For the purposes of this discussion, sizing materials will be limited to Starch, Dextrines, Softeners and Compounds.

Starch

The largest and most important constituent of the size-mixture is starch. For this reason, any trouble or irregularity in the work is usually attributed at once to the starch used. This opinion is sometimes justified. There are many kinds and types of starch, each possessing definite characteristics and properties. These properties bear a very definite relation to the results desired. The selection of the starch therefore should not be made in a haphazard manner, but should be based upon a careful investigation and consideration of all conditions. The final test is, beyond all question, the weaving quality of the yarn—this determines the production of the plant. The weaving quality should not be based upon the opinion of one or more operators, but should be calculated from accurate records taken at the loom.

First of all, for the best and most consistent results, a starch showing a high degree of purity should be selected. This would eliminate, except for the coarsest type of work, "Pearl Starch." "Pearl Starch" represents the first starch separation in the manufacturing process and is really the crudest form of starch which is commercially possible. Some plants use only "Pearl," others use "Pearl" on some work and purified starch on the more important grades. This practice frequently causes difficulty as the "Pearl Starch" sometimes is used on the wrong work. The tendency of the best managed plants is more and more towards the refined starches on account of their uniformity and reliability.

The refined starches may be divided into two classes, namely: "thick boiling starches" and "thin boiling starches." Corn starch is normally a thick boiling starch, but may be and is so modified that the thick boiling property is increased. On the other hand the proper treatment of the starch modifies it into a "thin boiling" starch. The textile manufacturer therefore has the option of selecting a "thick-boiling" or a "thin-boiling" starch according to his judgment of his requirements. As far as the sizing of yarn is concerned the "thick-boiling" starch does not possess the property of penetrating the yarn between the fibres, to the same extent as a thin boiling starch and therefore remains largely on the surface in the form of a coating. This coating is subject to "shedding" and the lack of penetration results in the yarn not receiving the full strength increase which proper sizing should impart. In the case of the "thin-boiling" starch, owing to its higher fluidity, the absorption by the yarn and penetration into the yarn are greater. Penetration insures an internal cementation of the fibres giving

the increased strength and improved weaving quality. Since the loss by "shedding" is considerably less than when most of the starch is on the surface of the yarn, a greater weight increase is also attained. Opinions will vary as to which type of starch is to be preferred. The important point is that the selection should be based upon an intelligent investigation of the individual conditions. The fact is that the selection of "thin-boiling" starches is increasing as they become better known and old time prejudices are outgrown. The "thin-boiling" starches are especially attractive because of the wide range of fluidities manufactured. They cover practically all grades of work. The man who knows can secure what he wants.

Dextrine

British Gum or Dextrine is frequently added to the size mixture to an extent of about 10% of the starch for the purpose of increasing the adhesive properties. There is sometimes good reason for this, but should be adopted with due reference to the conditions prevailing.

Softeners

Under the term "Softener" is understood tallow, fats, oils and waxes and numerous proprietary preparations containing one or more of these substances as a chief ingredient, compounded with starch, water and some metallic salt, chiefly calcium chloride or magnesium chloride. Sometimes zinc chloride or sodium sulphate is present. As far as softening value is concerned, this is entirely dependent upon the percentage of fatty or oily matter present. This should always bear a certain definite proportion to the starch present in the size mixture. If the fat content is deficient then it should be rein-

forced by the addition of straight tallow or its equivalent. Calcium chloride is used for its moisture absorbing quality. Zinc chloride has an antiseptic value. The presence of starch and water requires no comment.

Compounds

The term "Sizing Compound" and "Gum" are used very loosely and cover many varieties of sins and virtues. Usually these mixtures consist principally of water with some starch and calcium chloride, sometimes magnesium chloride. Not infrequently zinc chloride is present and occasionally a little tallow is incorporated.

Compounded Softeners and Sizing-Compounds in their effects will run all the way from beneficial to harmless and decidedly detrimental according to their compositions. For example if the effect of a "thick-boiling" starch is desired, then the compound should contain no ingredient which would have a thinning action on the size; conversely if a "thin-boiling" starch is used, no constituent having a thickening effect should be present. The attitude of the starch manufacturer towards softening and sizing compounds is governed entirely by the effect which they have upon starch. When the effect is beneficial, their use is encouraged; if they are harmless, no opposition is offered; but if they are detrimental, condemnation is inevitable.

It is perfectly manifest that no textile manufacturer should use any sort of compounded softener or gum without knowing very definitely its constitution. The composition in some cases will vary with the market prices of the more expensive components. No sizing formula can be properly balanced without this knowledge. Trustworthy infor-

mation of this character may be obtained without expense to the consumer.

Water

A final word in regard to the water used in mixing the size will not be out of place. The purer the water the better it is for sizing. Dirty or muddy water should be entirely prohibited. The so called "hard" waters should be avoided. The mineral salts which they contain in solution are transferred to the yarn, usually with undesirable results. When the main water supply is not sufficiently pure, the pure water from condensed steam should be collected and used in the size kettle.

Tables

Specific Gravity of Solutions of Sulphuric Acid (60°F.)

Degrees Baume	Specific Gravity 60° F.	Degrees Twaddell	Per Cent H_2SO_4
0	1.0000	0.0	0.00
1	1.0069	1.4	1.02
2	1.0140	2.8	2.08
3	1.0211	4.2	3.13
4	1.0284	5.7	4.21
5	1.0357	7.1	5.28
6	1.0432	8.6	6.37
7	1.0507	10.1	7.45
8	1.0584	11.7	8.55
9	1.0662	13.2	9.66
10	1.0741	14.8	10.77
11	1.0821	16.4	11.89
12	1.0902	18.0	13.01
13	1.0985	19.7	14.13
14	1.1069	21.4	15.25
15	1.1154	23.1	16.38
16	1.1240	24.8	17.53
17	1.1328	26.6	18.71
18	1.1417	28.3	19.89
19	1.1508	30.2	21.07
20	1.1600	32.0	22.25
21	1.1694	33.9	23.43
22	1.1789	35.8	24.61
23	1.1885	37.7	25.81
24	1.1983	39.7	27.03
25	1.2083	41.7	28.28
26	1.2185	43.7	29.53
27	1.2288	45.8	30.79
28	1.2393	47.9	32.05
29	1.2500	50.0	33.33
30	1.2609	52.2	34.63
31	1.2719	54.4	35.93
32	1.2832	56.6	37.26
33	1.2946	58.9	38.58
34	1.3063	61.3	39.92

Specific Gravity of Solutions of Sulphuric Acid (60°F). —Continued

Degrees Baume	Specific Gravity 60° F.	Degrees Twaddell	Per Cent H_2SO_4
35	1.3182	63.6	41.27
36	1.3303	66.1	42.63
37	1.3426	68.5	43.99
38	1.3551	71.0	45.35
39	1.3679	73.6	46.72
40	1.3810	76.2	48.10
41	1.3942	78.8	49.47
42	1.4078	81.6	50.87
43	1.4216	84.3	52.26
44	1.4356	87.1	53.66
45	1.4500	90.0	55.07
46	1.4646	92.9	56.48
47	1.4796	95.9	57.90
48	1.4948	99.0	59.32
49	1.5104	102.1	60.75
50	1.5263	105.3	62.18
51	1.5426	108.5	63.66
52	1.5591	111.8	65.13
53	1.5761	115.2	66.63
54	1.5943	118.7	68.13
55	1.6111	122.2	69.65
56	1.6292	125.8	71.17
57	1.6477	129.5	72.75
58	1.6667	133.3	74.36
59	1.6860	137.2	75.99
60	1.7059	141.2	77.67
61	1.7262	145.2	79.43
62	1.7470	149.4	81.30
63	1.7683	153.7	83.34
64	1.7901	158.0	85.66
64¼	1.7957	159.1	86.33
64½	1.8012	160.2	87.04
64¾	1.8068	161.4	87.81
65	1.8125	162.5	88.65
65¼	1.8182	163.6	89.55
65½	1.8239	164.8	90.60
65¾	1.8297	165.9	91.80
66	1.8354	167.1	93.19

By W. C. Ferguson and H. P. Talbot.

Specific Gravity of Solutions of Hydrochloric Acid (60° F.)

Degrees Baume	Specific Gravity	Degrees Twaddell	Per cent HCL
1.00	1.0069	1.38	1.40
2.00	1.0140	2.80	2.82
3.00	1.0211	4.22	4.25
4.00	1.0284	5.68	5.69
5.00	1.0357	7.14	7.15
5.25	1.0375	7.50	7.52
5.50	1.0394	7.88	7.89
5.75	1.0413	8.26	8.26
6.00	1.0432	8.64	8.64
6.25	1.0450	9.00	9.02
6.50	1.0469	9.38	9.40
6.75	1.0488	9.76	9.78
7.00	1.0507	10.14	10.17
7.25	1.0526	10.52	10.55
7.50	1.0545	10.90	10.94
7.75	1.0564	11.28	11.32
8.00	1.0584	11.68	11.71
8.25	1.0603	12.06	12.09
8.50	1.0623	12.46	12.48
8.75	1.0642	12.84	12.87
9.00	1.0662	13.24	13.26
9.25	1.0681	13.62	13.65
9.50	1.0701	14.02	14.04
9.75	1.0721	14.42	14.43
10.00	1.0741	14.82	14.83
10.25	1.0761	15.22	15.22
10.50	1.0781	15.62	15.62
10.75	1.0801	16.02	16.01
11.00	1.0821	16.42	16.41
11.25	1.0841	16.82	16.81
11.50	1.0861	17.22	17.21
11.75	1.0881	17.62	17.61
12.00	1.0902	18.04	18.01
12.25	1.0922	18.44	18.41
12.50	1.0943	18.86	18.82
12.75	1.0964	19.28	19.22
13.00	1.0985	19.70	19.63

Specific Gravity of Solutions of Hydrochloric Acid (60° F.)—Continued

Degrees Baume	Specific Gravity	Degrees Twaddell	Per cent HCL
13.25	1.1006	20.12	20.04
13.50	1.1027	20.54	20.45
13.75	1.1048	20.96	20.86
14.00	1.1069	21.38	21.27
14.25	1.1090	21.80	21.68
14.50	1.1111	22.22	22.09
14.75	1.1132	22.64	22.50
15.00	1.1154	23.08	22.92
15.25	1.1176	23.52	23.33
15.50	1.1197	23.94	23.75
15.75	1.1219	24.38	24.16
16.00	1.1240	24.80	24.57
16.10	1.1248	24.96	24.73
16.20	1.1256	25.12	24.90
16.30	1.1265	25.30	25.06
16.40	1.1274	25.48	25.23
16.50	1.1283	25.66	25.39
16.60	1.1292	25.84	25.56
16.70	1.1301	26.02	25.72
16.80	1.1310	26.20	25.89
16.90	1.1319	26.38	26.05
17.00	1.1328	26.56	26.22
17.10	1.1336	26.72	26.39
17.20	1.1345	26.90	26.56
17.30	1.1354	27.08	26.73
17..40	1.1363	27.26	26.90
17.50	1.1372	27.44	27.07
17.60	1.1381	27.62	27.24
17.70	1.1390	27.80	27.41
17.80	1.1399	27.98	27.58
17.90	1.1408	28.16	27.75
18.00	1.1417	28.34	27.92
18.10	1.1426	28.52	28.09
18.20	1.1435	28.70	28.26
18.30	1.1444	28.88	28.44
18.40	1.1453	29.06	28.61
18.50	1.1462	29.24	28.78

Specific Gravity of Solutions of Hydrochloric Acid (60° F.)—Continued

Degrees Baume	Specific Gravity	Degrees Twaddell	Per cent HCL
18.60	1.1471	29.42	28.95
18.70	1.1480	29.60	29.13
18.80	1.1489	29.78	29.30
18.90	1.1498	29.96	29.48
19.00	1.1508	30.16	29.65
19.10	1.1517	30.34	29.83
19.20	1.1526	30.52	30.00
19.30	1.1535	30.70	30.18
19.40	1.1544	30.88	30.35
19.50	1.1554	31.08	30.53
19.60	1.1563	31.26	30.71
19.70	1.1572	31.44	30.90
19.80	1.1581	31.62	31.08
19.90	1.1590	31.80	31.27
20.00	1.1600	32.00	31.45
20.10	1.1609	32.18	31.64
20.20	1.1619	32.38	31.82
20.30	1.1628	32.56	32.01
20.40	1.1637	32.74	32.19
20.50	1.1647	32.94	32.38
20.60	1.1656	33.12	32.56
20.70	1.1666	33.32	32.75
20.80	1.1675	33.50	32.93
20.90	1.1684	33.68	33.12
21.00	1.1694	33.88	33.31
21.10	1.1703	34.06	33.50
21.20	1.1713	34.26	33.69
21.30	1.1722	34.44	33.88
21.40	1.1732	34.64	34.07
21.50	1.1741	34.82	34.26
21.60	1.1751	35.02	34.45
21.70	1.1760	35.20	34.64
21.80	1.1770	35.40	34.83
21.90	1.1779	35.58	35.02
22.00	1.1789	35.78	35.21
22.10	1.1798	35.96	35.40
22.20	1.1808	36.16	35.59

Specific Gravity of Solutions of Hydrochloric Acid (60° F.)—Continued

Degrees Baume	Specific Gravity	Degrees Twaddell	Per cent HCL
22.30	1.1817	36.34	35.78
22.40	1.1827	36.54	35.97
22.50	1.1836	36.72	36.16
22.60	1.1846	36.92	36.35
22.70	1.1856	37.12	36.54
22.80	1.1866	37.32	36.73
22.90	1.1875	37.50	36.93
23.00	1.1885	37.70	37.14
23.10	1.1895	37.90	37.36
23.20	1.1904	38.08	37.58
23.30	1.1914	38.28	37.80
23.40	1.1924	38.48	38.03
23.50	1.1934	38.68	38.26
23.60	1.1944	38.88	38.49
23.70	1.1953	39.06	38.72
23.80	1.1963	39.26	38.95
23.90	1.1973	39.46	39.18
24.00	1.1983	39.66	39.41
24.10	1.1993	39.86	39.64
24.20	1.2003	40.06	39.86
24.30	1.2013	40.26	40.09
24.40	1.2023	40.46	40.32
24.50	1.2033	40.66	40.55
24.60	1.2043	40.86	40.78
24.70	1.2053	41.06	41.01
24.80	1.2063	41.26	41.24
24.90	1.2073	41.46	41.48
25.00	1.2083	41.66	41.72
25.10	1.2093	41.86	41.99
25.20	1.2103	42.06	42.30
25.30	1.2114	42.28	42.64
25.40	1.2124	42.48	43.01
25.50	1.2134	42.68	43.40

By W. C. Ferguson.

Specific Gravity of Solutions of Acetic Acid (15° C.)

Specific Gravity	% Acetic Acid	Specific Gravity	% Acetic Acid	Specific Gravity	% Acetic Acid	Specific Gravity	% Acetic Acid
0.9992	0	1.0363	26	1.0623	51	1.0747	76
1.0007	1	1.0375	27	1.0631	52	1.0748	77
1.0022	2	1.0388	28	1.0638	53	1.0748	78
1.0037	3	1.0400	29	1.0646	54	1.0748	79
1.0052	4	1.0412	30	1.0653	55	1.0748	80
1.0067	5	1.0424	31	1.0660	56	1.0747	81
1.0083	6	1.0436	32	1.0666	57	1.0746	82
1.0098	7	1.0447	33	1.0673	58	1.0744	83
1.0113	8	1.0459	34	1.0679	59	1.0742	84
1.0127	9	1.0470	35	1.0685	60	1.0739	85
1.0142	10	1.0481	36	1.0691	61	1.0736	86
1.0157	11	1.0492	37	1.0697	62	1.0731	87
1.0171	12	1.0502	38	1.0702	63	1.0726	88
1.0185	13	1.0513	39	1.0707	64	1.0720	89
1.0200	14	1.0523	40	1.0712	65	1.0713	90
1.0214	15	1.0533	41	1.0717	66	1.0705	91
1.0288	16	1.0543	42	1.0721	67	1.0696	92
1.0242	17	1.0552	43	1.0725	68	1.0686	93
1.0256	18	1.0562	44	1.0729	69	1.0674	94
1.0270	19	1.0571	45	1.0733	70	1.0660	95
1.0284	20	1.0580	46	1.0737	71	1.0644	96
1.0298	21	1.0589	47	1.0740	72	1.0625	97
1.0311	22	1.0598	48	1.0742	73	1.0604	98
1.0324	23	1.0607	49	1.0744	74	1.0580	99
1.0337	24	1.0615	50	1.0746	75	1.0553	100
1.0350	25	.....	.....	.....	.....	.....	.....

By Oudemans.

Specific Gravity of Solutions of Ammonia

Degrees Baume	Specific Gravity 60° F.	Per cent Ammonia	Degrees Baume	Specific Gravity 60° F.	Per cent Ammonia	Degrees Baume	Specific Gravity 60° F.	Per cent Ammonia
10.00	1.0000	.00	16.50	.9556	11.18	23.00	.9150	23.52
10.25	.9982	.40	16.75	.9540	11.64	23.25	.9135	24.01
10.50	.9964	.80	17.00	.9524	12.10	23.50	.9121	24.50
10.75	.9947	1.21	17.25	.9508	12.56	23.75	.9106	24.99
11.00	.9929	1.62	17.50	.9492	13.02	24.00	.9091	25.48
11.25	.9912	2.04	17.75	.9475	13.49	24.25	.9076	25.97
11.50	.9894	2.46	18.00	.9459	13.96	24.50	.9061	26.46
11.75	.9876	2.88	18.25	.9444	14.43	24.75	.9047	26.95
12.00	.9859	3.30	18.50	.9428	14.90	25.00	.9032	27.44
12.25	.9842	3.73	18.75	.9412	15.37	25.25	.9018	27.93
12.50	.9825	4.16	19.00	.9396	15.84	25.50	.9003	28.42
12.75	.9807	4.59	19.25	.9380	16.32	25.75	.8989	28.91
13.00	.9790	5.02	19.50	.9365	16.80	26.00	.8974	29.40
13.25	.9773	5.45	19.75	.9349	17.28	26.25	.8960	29.89
13.50	.9756	5.88	20.00	.9333	17.76	26.50	.8946	30.38
13.75	.9739	6.31	20.25	.9318	18.24	26.75	.8931	30.87
14.00	.9722	6.74	20.50	.9302	18.72	27.00	.8917	31.36
14.25	.9705	7.17	20.75	.9287	19.20	27.25	.8903	31.85
14.50	.9689	7.61	21.00	.9272	19.68	27.50	.8889	32.34
14.75	.9672	8.05	21.25	.9256	20.16	27.75	.8875	32.83
15.00	.9655	8.49	21.50	.9241	20.64	28.00	.8861	33.32
15.25	.9639	8.93	21.75	.9226	21.12	28.25	.8847	33.81
15.50	.9622	9.38	22.00	.9211	21.60	28.50	.8833	34.30
15.75	.9605	9.83	22.25	.9195	22.08	28.75	.8819	34.79
16.00	.9589	10.28	22.50	.9180	22.56	29.00	.8805	35.28
16.25	.9573	10.73	22.75	.9165	23.04	.....	.....	.....

According to W. C. Ferguson.

Specific Gravity of Solutions of Pure Caustic Soda

At 15° C. (59° F.)

Specific Gravity	Degrees Baume	Degrees Twaddell	Per cent Caustic Soda NaOH	Specific Gravity	Degrees Baume	Degrees Twaddell	Per cent Caustic Soda NaOH
1.007	1	1.4	0.61	1.220	26	44.0	19.58
1.014	2	2.8	1.20	1.231	27	46.2	20.59
1.022	3	4.4	2.00	1.241	28	48.2	21.42
1.029	4	5.8	2.71	1.252	29	50.4	22.64
1.036	5	7.2	3.35	1.263	30	52.6	23.67
1.045	6	9.0	4.00	1.274	31	54.8	24.81
1.052	7	10.4	4.64	1.285	32	57.0	25.80
1.060	8	12.0	5.29	1.297	33	59.4	26.83
1.067	9	13.4	5.87	1.308	34	61.6	27.80
1.075	10	15.0	6.55	1.320	35	64.0	28.83
1.083	11	16.6	7.31	1.332	36	66.4	29.93
1.091	12	18.2	8.00	1.345	37	69.0	31.22
1.100	13	20.0	8.68	1.357	38	71.4	32.47
1.108	14	21.6	9.42	1.370	39	74.0	33.69
1.116	15	23.2	10.06	1.383	40	76.6	34.96
1.125	16	25.0	10.97	1.397	41	79.4	36.25
1.134	17	26.8	11.84	1.410	42	82.0	37.47
1.142	18	28.4	12.64	1.424	43	84.8	38.80
1.152	19	30.4	13.55	1.438	44	87.6	39.99
1.162	20	32.4	14.37	1.453	45	90.6	41.41
1.171	21	34.2	15.13	1.468	46	93.6	42.83
1.180	22	36.0	15.91	1.483	47	96.6	44.38
1.190	23	38.0	16.77	1.498	48	99.6	46.15
1.200	24	40.0	17.67	1.514	49	102.8	47.60
1.210	25	42.0	18.58	1.530	50	106.0	49.02

(According to Solway Process Co.)

Specific Gravity of Solutions of Sodium Carbonate

At 15° C. (59° F.)

Specific Gravity	Degrees Baume	Degrees Twaddell	Per Cent by Weight	
			Na_2CO_3	$Na_2CO_3+10H_2O$
1.007	1	1.4	0.67	1.81
1.014	2	2.8	1.33	3.59
1.022	3	4.4	2.09	5.64
1.029	4	5.8	2.76	7.44
1.036	5	7.2	3.43	9.25
1.045	6	9.0	4.29	11.6
1.052	7	10.4	4.94	13.3
1.060	8	12.0	5.71	15.4
1.067	9	13.4	6.37	17.2
1.075	10	15.0	7.12	19.2
1.083	11	16.6	7.88	21.3
1.091	12	18.2	8.62	23.2
1.100	13	20.0	9.43	25.4
1.108	14	21.6	10.2	27.5
1.116	15	23.2	10.9	29.5
1.125	16	25.0	11.8	31.9
1.134	17	26.8	12.6	34.0
1.142	18	28.4	13.5	35.5
1.152	19	30.4	14.2	38.4

(According to Solway Process Co.)

Specific Gravity of Calcium Chloride Solutions. (65° F.)

Specific Gravity	% $CaCl_2$	Specific Gravity	% $CaCl_2$
1.0039	0.507	1.1575	18.245
1.0079	1.014	1.1622	18.752
1.0119	1.521	1.1671	19.259
1.0159	2.028	1.1719	19.766
1.0200	2.535	1.1768	20.272
1.0241	3.041	1.1816	20.779
1.0282	3.548	1.1865	21.286
1.0323	4.055	1.1914	21.793
1.0365	4.562	1.1963	22.300
1.0407	5.068	1.2012	22.806
1.0449	5.575	1.2062	23.313
1.0491	6.082	1.2112	23.820
1.0534	6.587	1.2162	24.327
1.0577	7.096	1.2212	24.834
1.0619	7.601	1.2262	25.340
1.0663	8.107	1.2312	25.847
1.0706	8.611	1.2363	26.354
1.0750	9.121	1.2414	26.861
1.0794	9.625	1.2465	27.368
1.0838	10.136	1.2516	27.874
1.0882	10.643	1.2567	28.381
1.0927	11.150	1.2618	28.888
1.0972	11.657	1.2669	29.395
1.1017	12.164	1.2721	29.902
1.1062	12.670	1.2773	30.408
1.1107	13.177	1.2825	30.915
1.1153	13.684	1.2877	31.422
1.1199	14.191	1.2929	31.929
1.1246	14.698	1.2981	32.436
1.1292	15.204	1.3034	32.942
1.1339	15.711	1.3087	33.449
1.1386	16.218	1.3140	33.956
1.1433	16.725	1.3193	34.463
1.1480	17.232	1.3246	34.970
1.1527	17.738	1.3300	35.476

According to Schiff.

Specific Gravity of Magnesium Chloride Solution (75° F.)

Specific Gravity	% $MgCl_2$	Specific Gravity	% $MgCl_2$
1.0069	0.936	1.1519	19.656
1.0138	1.872	1.1598	20.592
1.0207	2.808	1.1677	21.528
1.0276	3.744	1.1756	22.464
1.0345	4.680	1.1836	23.400
1.0415	5.616	1.1918	24.336
1.0485	6.552	1.2000	25.272
1.0556	7.488	1.2083	26.208
1.0627	8.424	1.2167	27.144
1.0698	9.360	1.2252	28.080
1.0770	10.296	1.2338	29.016
1.0842	11.232	1.2425	29.952
1.0915	12.168	1.2513	30.888
1.0988	13.104	1.2602	31.824
1.1062	14.040	1.2692	32.760
1.1137	14.976	1.2783	33.696
1.1212	15.912	1.2875	34.632
1.1288	16.848	1.2968	35.568
1.1364	17.784	1.3063	36.504
1.1441	18.720	1.3159	37.440

According to Schiff.

Specific Gravity of Zinc Chloride Solutions (67° F.)

Specific Gravity	% $ZnCl_2$	Specific Gravity	% $ZnCl_2$
1.045	5.00	1.352	35.00
1.091	10.00	1.420	40.00
1.137	15.00	1.488	45.00
1.186	20.00	1.566	50.00
1.238	25.00	1.650	55.00
1.291	30.00	1.740	60.00

By Kremers.

Comparison of Hydrometer Scales with Baume Degrees As the Basis

°Baume	°Twaddell	Specific Gravity	°Baume	°Twaddell	Specific Gravity
1	1.4	1.007	36	66.4	1.332
2	2.8	1.014	37	69.	1.345
3	4.4	1.022	38	71.4	1.357
4	5.8	1.029	39	74.	1.370
5	7.4	1.037	40	76.6	1.383
6	9.	1.045	41	79.4	1.397
7	10.4	1.052	42	82.	1.410
8	12.	1.060	43	84.8	1.424
9	13.4	1.067	44	87.6	1.438
10	15.	1.075	45	90.6	1.453
11	16.6	1.083	46	93.6	1.468
12	18.2	1.091	47	96.6	1.483
13	20.	1.100	48	99.6	1.498
14	21.6	1.108	49	102.8	1.514
15	23.2	1.116	50	106.	1.530
16	25.	1.125	51	109.2	1.546
17	26.8	1.134	52	112.6	1.563
18	28.4	1.142	53	116.	1.580
19	30.4	1.152	54	119.4	1.597
20	32.4	1.162	55	123.	1.615
21	34.2	1.171	56	126.8	1.634
22	36.	1.180	57	130.4	1.652
23	38.	1.190	58	134.2	1.671
24	40.	1.200	59	138.2	1.691
25	42.	1.210	60	142.2	1.711
26	44.	1.220	61	146.4	1.732
27	46.2	1.231	62	150.6	1.753
28	48.2	1.241	63	154.8	1.774
29	50.4	1.252	64	159.2	1.796
30	52.6	1.263	65	163.8	1.819
31	54.8	1.274	66	168.4	1.842
32	57.	1.285			
33	59.4	1.297			
34	61.6	1.308			
35	64.	1.320			

According to Solway Process Co.

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Memoranda

Memoranda

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SOUTHEASTERN MASSACHUSETTS UNIVERSITY
TS1488.C3
Sizing hints for the practical slasher–m
3 2922 00078 072 3

SPECIAL COLL TS1488.C3 1919
Cathcart, William Richard,
1869-
Sizing hints for the
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